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ScienceDirect

Procedia Engineering 104 (2015) 65 – 75

Procedia Engineering

www.elsevier.com/locate/procedia

Scientific and Technological Experiments on Automatic Space Vehicles and Small Satellites

Generation of land remote sensing satellites conceptual design based on regard to required efficiency indices

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Abstract

Approaches to the choice of main design parameters and conceptual design of land remote sensing satellites are considered. The approach based on providing required efficiency indices of the spacecraft has number of advantages. It allows forming such a sequence of design procedures, which provides a choice of the basic design parameters and formation of conceptual design with a minimum number of iterations. Main approach items are discussed.

Peer-review under responsibility of organizing committee of the Scientific and Technological Experiments on Automatic Space Vehicles and Small Satellites (SPEXP2014)

Keywords: Spacecraft, target efficiency, conceptual design, problem-oriented designing system

1. Approaches to generation of land remote sensing satellites conceptual design

There exist a couple of approaches to the choice of main design parameters and conceptual design of land remote sensing satellites (LRSS):

- based on heuristic method, when the satellite designing starts with a blank slate (it is typical for completely new projects with on-board systems utilizing advanced principles);

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Peer-review under responsibility of organizing committee of the Scientific and Technological Experiments on Automatic Space Vehicles and Small Satellites (SPEXP2014)
doi:10.1016/j.proeng.2015.04.098

- using allocation of target and support systems in the satellite body with prescribed envelope;
- based on prototypes improvement (such as Yantar, Neman, Resurs satellites);
- using improvement of target systems allocated in payload section without changes in support systems section (such as, for instance, universal mother space vehicle Yahta or spacecraft Condor);
- using allocation of telescopic optical system and sensitive gages at temperature-stabilized platform (LRSS Pleads);
- based on use of several target systems with limited total mass and their integrated work, etc.

When implementing these approaches, all target indices must certainly comply with the requirements.

2. Generation of spacecraft conceptual design based on regard to required efficiency indices

The design approach based on regard to required efficiency indices deserves specific attention. The set of such indices include surveillance frequency, ground resolution, swath width, field of view width, productivity, operational efficiency, operating lifetime, and others. Other indices have lesser impact on spacecraft conceptual design.

Essence of the proposed methodology is that it allows forming such a sequence of design procedures, which provides a choice of the basic design parameters and formation of conceptual design with a minimum number of iterations. Spacecraft design parameters are chosen with use of mathematical models relating these parameters to target efficiency indices. The methodology supposes usage of existing and newly developed models for estimation of target parameters, mass-dimensional, inertia, energy, and other characteristics of the spacecraft.

Optimization of the basic LRSS design parameters is realized in implicit form without setting the mathematical programming problem, which would require formulation of objective functions and limitations. It allows realizing so called exact approximation concept. Obtained mass-dimensional, inertia, energy, and other characteristics of the spacecraft provide required efficiency indices (neither insufficient, nor excessive). Verification of all target indices compliance with requirements is fulfilled with the help of simulation the spacecraft operation.

The approach is particularly useful when creating new spacecraft, dimensions and shape of which are not associated with substantial restrictions concerning their placement on the launcher, for example, for generation of small LRSS conceptual design.

Advantage of the approach is that the designed spacecraft will have potentially better mass-dimensional, inertia, energy, and other characteristics than the spacecraft designed, for example, through the development of a prototype with borrowing of some elements.

On the other hand, it should be kept in mind that sometimes it is economically reasonable not to create more advanced elements if one can borrow an existing, proven operating, albeit less efficient ones.

What is more, mass-dimensional, inertia, energy characteristics obtained by means of the method, may be regarded as reference ones characterizing the degree of space vehicles perfection.

Given data: surveillance frequency, ground resolution, swath width, field of view width, productivity, operational efficiency, operating lifetime.

Limitations: orbits are circular, sun synchronous; orbit altitude does not exceed 1000 km; launcher maximum payload capacity and fairing zone limitations are given.

Tools: predeveloped parameterized 3D models of the main spacecraft elements.

3. Algorithm of the approach realization

The algorithm is shown in Fig. 1. Let us examine it in more detail.

3.1. Acquisition and processing of statistical data on the space systems and satellites

This item is necessary, first, for taking into account resent advantages in spacecraft design and, secondly, for clarification of regression relationships that are to be applied in methodical ware and software in order to provide adequacy of used mathematical models (accuracy of the spacecraft mass-dimensional characteristic calculation